ACCURATE LAND COVER DEVELOPMENT FOR RAPIDLY GROWING WATERSHEDS

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Abstract. Accurate digital land cover data is vital to correctly estimating the impacts of nonpoint source pollution on a watershed. However, producing reasonable digital data characterizing current land conditions in a watershed can be challenging due to recent rapid growth in historically rural areas, insufficient monetary and personnel resources, and technical difficulties. This paper describes the iterative process used to create digital existing and future land cover data for use in the Forsyth County, Hall County, and the City of Gainesville Community Watershed Assessment. Significant efforts were made to develop realistic, contiguous data that characterize a combination of land cover and land use in a geographic information system (GIS) format, using the most recent data sources possible. These efforts included integrating numerous different hard copy and digital data sources to arrive at reasonable existing and future land cover information that the project stakeholders found acceptable for water quality modeling purposes.

INTRODUCTION

Realistic digital land cover data is vital to correctly estimating the impacts of non-point source pollution on a watershed. Existing land cover data is utilized in both the watershed modeling and biological elements of a Watershed Assessment, while future land cover data is necessary for modeling future watershed conditions and developing effective watershed management strategies. Suitable data should reflect a snapshot of land cover conditions during the Assessment's biological and water quality sampling events. It should also be rectified to a land classification system that articulates the level of imperviousness and the potential for sediment runoff.

Acceleration of growth in Forsyth County, Hall County and the City of Gainesville, located in northeast Georgia around Lake Sidney Lanier (fig.1), over the past 5 to 10 years deemed existing digital land cover from the 1970s and 1980s obsolete. While each of the municipalities have active planning departments, their existing land cover data was not suitable for use in the watershed assessment for a variety of reasons. The data was either not in a digital format, not current given the rapid growth in the region, or it delineated land cover based on parcel boundaries versus actual on the ground conditions.

BACKGROUND

Located approximately 45 miles northeast of metropolitan Atlanta via I-85 and I-985 or Georgia 400, Forsyth County and Hall County, Georgia are both experiencing tremendous growth. In particular, the US Census Bureau identified Forsyth as the fastest growing county in the country in 1998 and the fastest in the state in 1999. The two Counties share a border formed mostly by Lake Sidney Lanier, a Corps of Engineers reservoir representing approximately 8 percent of each county's total area. With almost 7 million visitors annually, Lake Lanier is one of the most visited federally operated lakes in the nation. Figure 1 shows the study area with respect to the region and major drainage basins. The study area for the land cover analysis also included small portions of adjacent counties. These areas were included for water quality modeling purposes to characterize runoff from those streams originating outside of Forsyth or Hall County.

Historically, the counties were rural in character with the exception of light industrial, commercial and residential lands clustered around the cities of Gainesville and Cumming as illustrated in Figure 2. Land Use / Land Cover data from EPA's BASINS program, created in the 1970s, identifies forested and agricultural lands, including numerous poultry operations, as the dominant historical land uses (90 percent) in the study area.

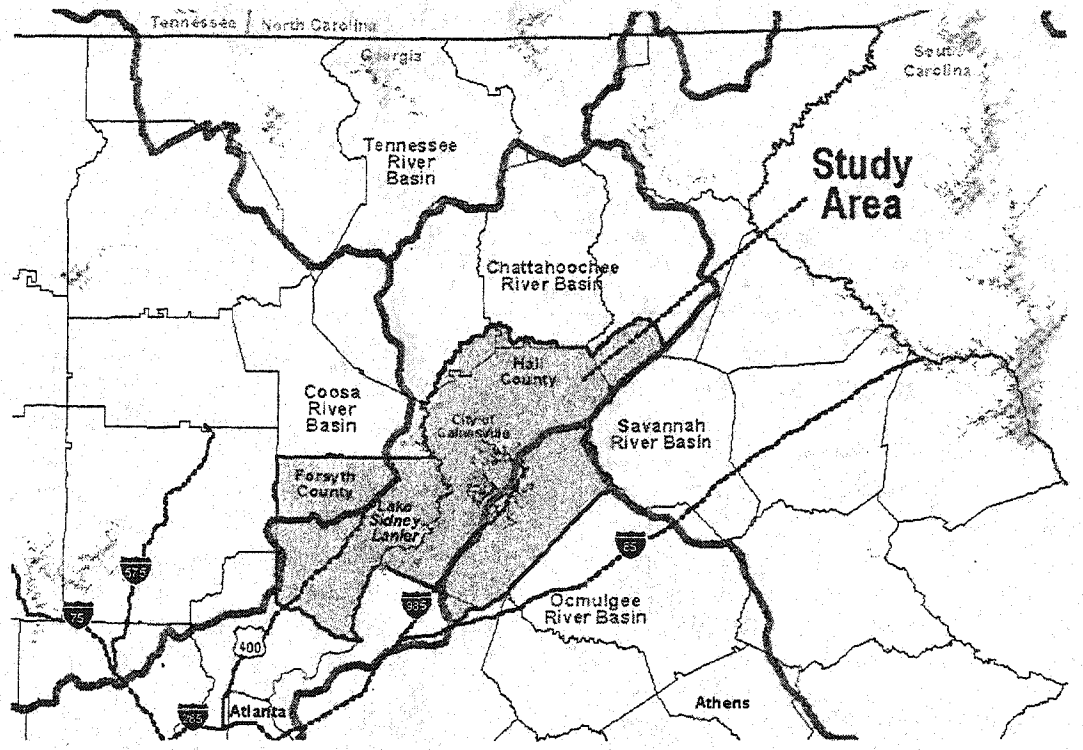

Figure 1. Location Map of Forsyth County, Hall County and the City of Gainesville Community Watershed Assessment Study Area.

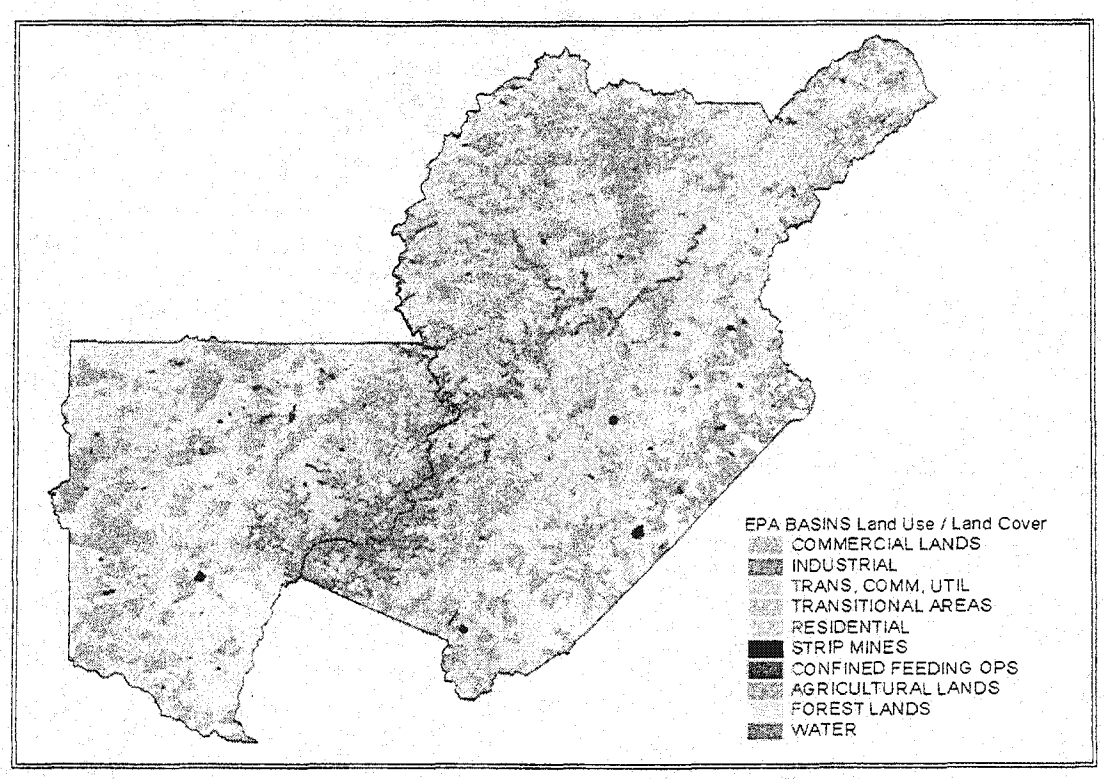

Figure 2. Original BASINS Land Use / Land Cover Data.

While there were multiple land cover sources for the study area, none of the readily available data adequately captured the tremendous growth that had occurred between 1994 and 1999. Multiple factors are fueling land use / land cover changes in the study area:

- Major transportation corridors, Georgia 400 and Interstate 985, link the area with metropolitan Atlanta and it's job markets;
- Diversifying economies within the study area are supporting balanced local growth including the addition of technology firms and the relocation of the Atlanta Falcons training camp to Hall County;
- A continuing housing boom on the north side of Atlanta is forcing developers to keep moving further out, as affordable land becomes scarce and building moratoriums are enacted because of lagging infrastructure;
- Vacation cottage / second home communities around Lake Lanier are being redeveloped or converted into primary residences.
- The Chattahoochee River National Recreation Area in Forsyth County and Lake Lanier contribute significantly to the quality of life.

Forsyth County, Hall County, and the City of Gainesville (Hall County) agreed to work together under an inter-governmental agreement to administer a Community-wide Watershed Assessment since large portions of each municipality drains to the Chattahoochee River Basin and Lake Lanier. The Etowah Basin in Forsyth County and the Oconee Basin in Hall County were also included in the watershed assessment. (Fig.1) This collaborative approach was designed to promote consistency in the water quality and biological data, the pollutant runoff and loading estimates, water quality modeling, and ultimate watershed management strategies. An inter-governmental agreement for the watershed assessment was signed on March 25, 1999.

To facilitate the public communication aspect of this project, the study area was further subdivided into 12 "community watersheds". The creation of community watersheds allowed the project team to focus communication efforts on water quality issues specific to each area and to encourage a more vigorous dialogue with community residents about the potential solutions that would be most effective within their community.

APPROACH

The approach used to develop land cover data for the Forsyth County, Hall County and City of Gainesville Community Watershed Assessment took into account a tight schedule, specific model inputs, and the need to integrate data from a variety of formats and sources. The different components of the land cover development approach are described below.

Coordination with the municipal planning departments. This took place throughout the Watershed Assessment to ensure that the land cover development efforts were reasonable based on their knowledge of the study area. Three meetings were held with the directors of each planning department and a representative from the Georgia Mountain Regional Development Center, the regional planning agency for the study area.

Review of readily available land cover data sources for the study area. Potential data sources included county and regional planning departments, state and federal agencies, universities and data vendors.

Assess age, accuracy and the appropriateness of the land cover information and its corresponding classification system. The goal was to have digital existing land cover files that characterized conditions during the Watershed Assessment's field activities in the summer of 1999. The land cover classification system used also needed to correlate the proper runoff coefficients given the level of imperviousness of each land cover type.

Identify resources that could be used to develop an accurate land cover product. Potential land cover resources included recent orthophotos, USGS Quadrangles, National Wetlands Inventory maps and digital park, utility and transportation data.

Creation and processing of land cover data. All processing was performed in ESRI's ArcView© and ArcInfo©, geographic information systems (GIS) software. A variety of identity, or overlay, functions were performed to transfer land cover attribute data from one data source to another. On-screen digitizing captured additional detail from aerial photography. Quality assurance was a vital component of this process because so much of the editing and processing was done in ArcView. All GIS files that are processed multiple times should be closely reviewed for duplicate data records and overlapping polygons to ensure that the final land cover area calculations are correct. After all the GIS processing was complete, the ArcView shape files were then converted to ArcInfo coverages for cleaning and creation of topology.

Development of digital future land cover data for use in future water quality modeling and in the watershed management plan. This component

included the initial collection of municipal and regional long range planning documents, research on population / development trends and input from local officials / planners. Future land use maps are relatively general by nature so a strict interpretation of the municipal data would not accurately reflect the impact of land cover conditions on future water quality. As a result, the existing land cover was used as the starting point for the development of reasonable future land cover for the study area. The Forsyth County future land use data was available digitally so an identity was performed on the existing land cover in the GIS that added the future land use code to each land cover polygon. Once this future land use code was added, a series of queries could be done to reclassify the undeveloped land from the existing land cover into its future classification. Because of incompatible file formats, the future land use information provided by Hall County and the City of Gainesville was manually interpreted onto the existing land use.

Estimate impacts of land development patterns on future water quality using a variety of future scenarios such as traditional suburban development versus cluster development. A variety of factors can be altered using the GIS and GIS based water quality model to anticipate the impact of an areas future growth on its water quality. A review of local development ordinances should reveal whether an area has mandatory stream buffers and other natural resource protection areas. These can be easily added to the future land cover to demonstrate the municipalities' intentions to protect these sensitive areas and to take these areas out of the developed land equation.

EXISTING LAND COVER DEVELOPMENT

The base digital information was taken US EPA BASINS because of its continuity across the region and its relative accuracy in characterizing forest lands, agricultural lands, and wetlands. While checked for general accuracy in the early 1990s, this base data mostly illustrates land cover / land use conditions during the 1970s. Figure 2 shows the original BASINS, considered historical, land use that served as the starting point for developing the existing land cover data. Three data sources were used to develop the land cover for the Forsyth County portion of the study area.

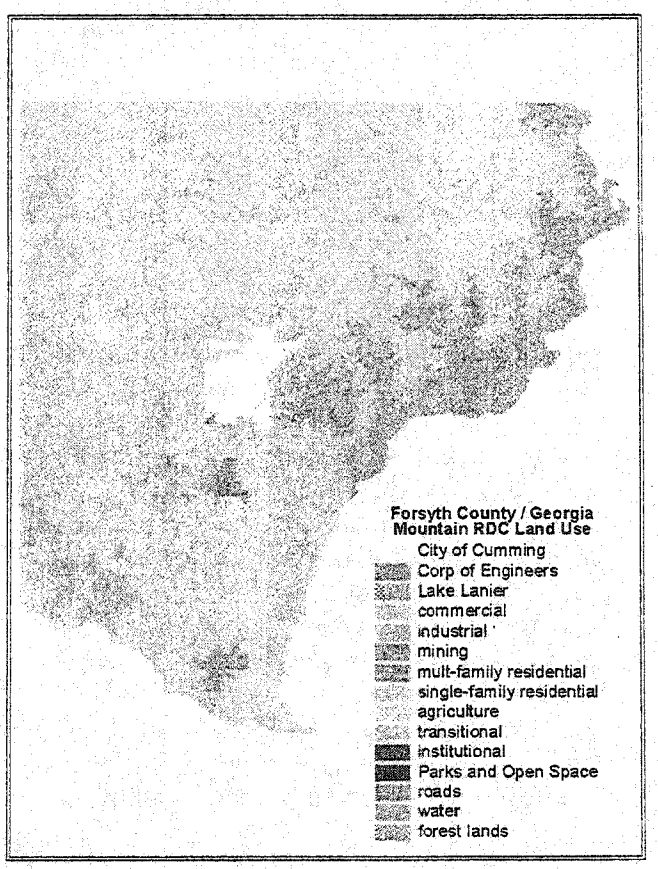

Figure 3. Forsyth County Original Existing Land Use developed by Georgia Mountain RDC.

Forsyth County and the Georgia Mountain Regional Development Center provided GIS-based existing land use (fig.3) for the county that was used to generally identify commercial, industrial, and residential lands. However, this data did not include land use for the City of Cumming or for U.S. Corps of Engineers lands along Lake Lanier. This additional detail was added by onscreen digitizing from DigiAir digital, color aerial photography flown during January of 1999. The DigiAir aerials were also used to identify lands currently transitioning from forested or agriculture to a higher density, more impervious form of development, such as commercial or residential. The aerials further identified confined feeding operations/poultry operations and actual extent of Georgia 400.

Four data sources were used to develop the basin land cover in Hall County. The base digital information was also taken from BASINS. The Hall County and City of Gainesville Planning Department provided hard copy maps developed in July of 1999 approximating the existing land use along the State Route 365, Winder Highway, Athens Highway

corridors, and for southern Hall County. This information was used to generally identify commercial, industrial, and residential lands. However, it did not include land cover for all of the City of Gainesville or northern Hall County. Additional detail for the BASINS data was derived from the DigiAir aerial photography though the aerial extent was limited to southern Hall County and the City of Gainesville. Land cover for the Chattahoochee River Basin in northeast Hall and Mud Creek-South and Flowery Branch in southwestern Hall were further augmented using land use data from the Tennessee Valley Authority's Clean Water Initiative, Non-Point Source Pollution Pilot Program. Hall County and GAEPD provided this land use data, developed from 1996 aerials.

Figure 4 demonstrates the relative size, shape, and location of the existing land cover patterns based on these data sources. For the purposes of the Forsyth County, Hall County, and the City of Gainesville Community Watershed Assessment, land use and land cover in the basin is characterized as one of the following:

1. Low-density residential–single family residential lands ranging from rural residential to medium-density residential with lots no smaller than one-third of an acre
2. High-density residential–apartments, mobile homes, and single-family residences on less than one-third of an acre
3. Commercial–primarily consists of service-based operations, such as shopping centers, strip malls, and restaurants
4. Industrial–includes manufacturing, warehouses, and mining operations
5. Roads/highways- primarily Interstates
6. Institutional–schools, churches, and government facilities.
7. Open space and parks–municipal parks, cemeteries, golf courses, utility transmission corridors, and open space
8. Agriculture—pasture lands and row crops
9. Confined feeding operations–primarily poultry operations, this category did not include dairy operations unless concentrated feeding areas (such as barns) were identified from aerial photography.
10. Forest lands
11. Wetlands
12. Water

FUTURE LAND COVER DEVELOPMENT

Development of a comprehensive watershed management plan is dependent on the anticipated changes in land cover. Future land cover and the anticipated pollutant loadings from this land cover affect the recommendations for watershed management. Therefore, development of reasonable digital future land cover data for the study area was critical for the water quality model to predict future pollutant loadings.

The existing land cover served as the starting point for creating the necessary future land cover GIS files for input into the model. The Future Land Use Element, developed by the City of Gainesville/Hall County Planning Department and a 13-member Citizens Advisory Committee (1998-1999), reflects an analysis of the general development trends being seen in the Hall County portion of the study area. It served to guide what the remaining agricultural or forested lands would eventually develop into.

The Land Use Element developed by the Forsyth County Master Land Use Committee (1997-1998) reflects a detailed analysis of the general development trends being seen in the County. The Forsyth County Department of Planning and Development provided a digital version of their future land use that was used to overlay the existing land cover. A County land use code was assigned to each polygon (GIS unit) in the existing land cover. Once this information was added to the existing land cover it could be queried for updating based on the County's general future land use while still keeping the detail of the existing land cover information.

Future land cover in the study area, estimated for the year 2020, is expected to reflect the conversion of much of the remaining forested and agricultural lands to either low-density residential land or commercial/industrial land. Conservation Land, a new land cover category, was added to reflect each County's intentions to protect certain areas of the study area from intense development. This includes approximately 18,000 acres of buffers, wetlands, and flood plains along the major rivers and streams in Forsyth County. Sawnee Mountain, located northwest of the City of Cumming, forms the boundary between the Chattahoochee River/Lake Lanier and Etowah River Drainage Basins and is also targeted for conservation in the future. The future land cover also reflects the reclassification of the numerous utility corridors in Hall County from Parks and Open Space to the new Communication and Utilities category. Figure 5 demonstrates the relative size, shape, and

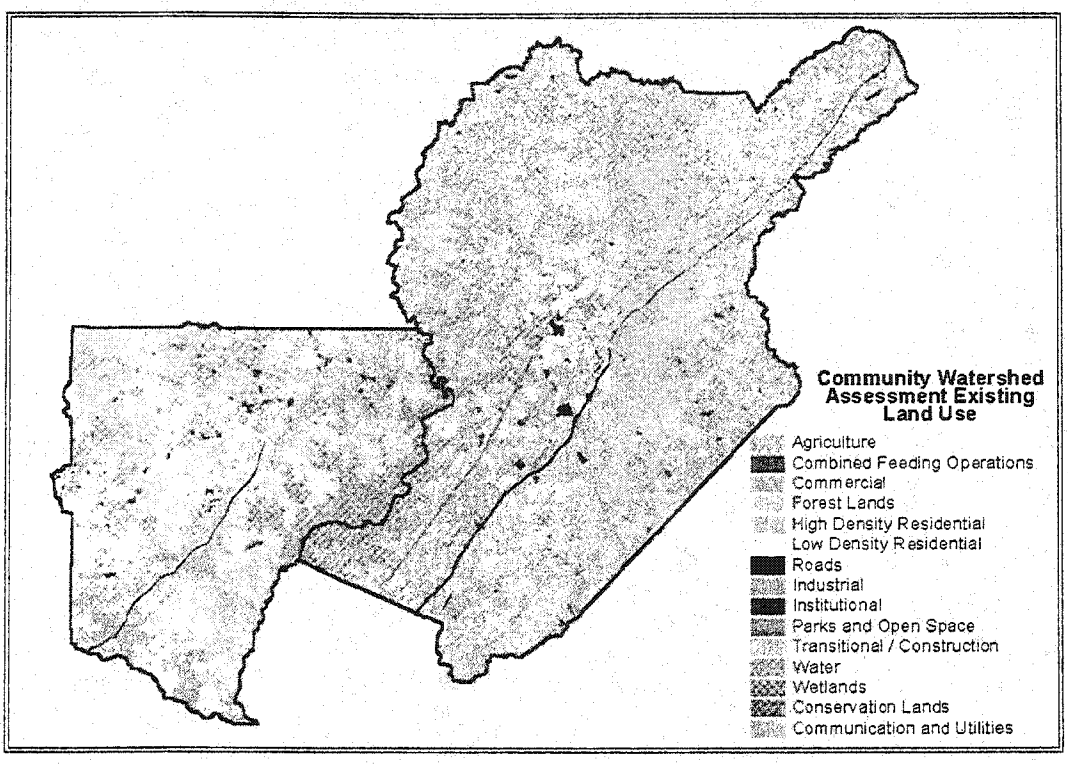

Figure 4. Existing Land Cover Data for the Community Watershed Assessment

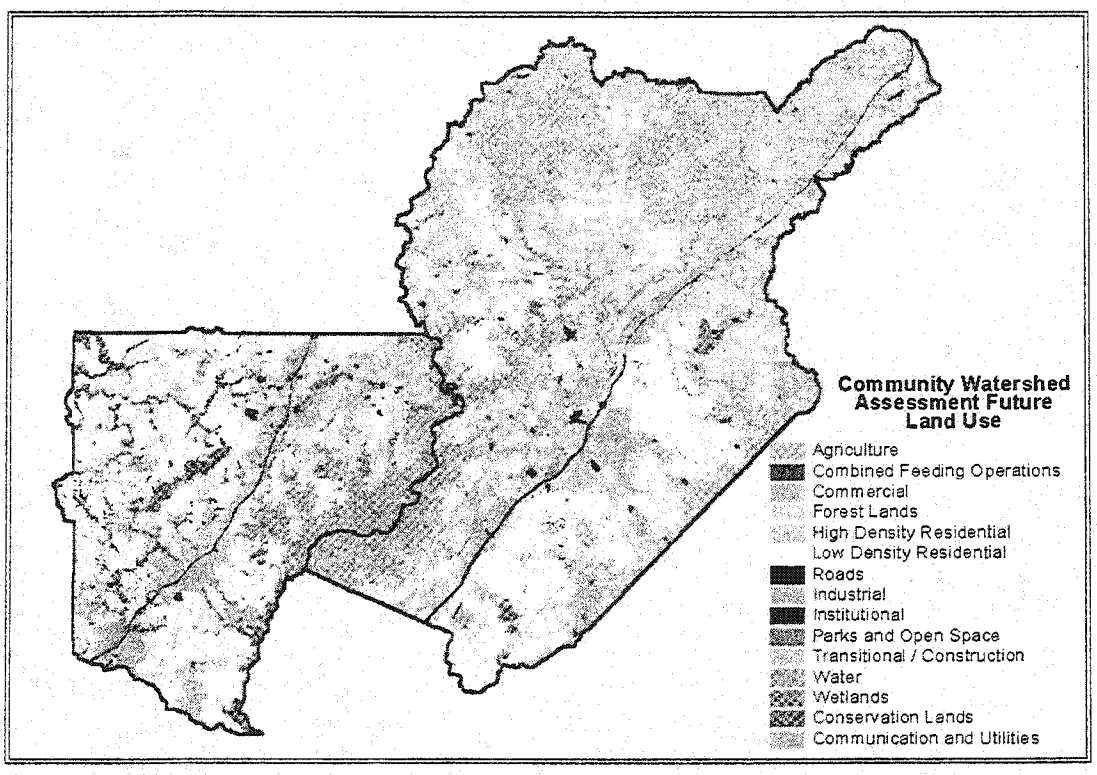

Figure 5. Future Land Cover Data for the Community Watershed Assessment

location of future land cover patterns based on these data sources.

RESULTS

Table 1 presents a comparison of the major land cover categories for the Forsyth County, Hall County, and the City of Gainesville Community Watershed Assessment study area. It demonstrates the significant changes that have occurred in the study area over the past 20 to 30 years while illustrating what future conditions may be like if each entities future land use plans are implemented. Forested lands were predominant in the historical and existing land cover representing approximately 64 percent and 50 percent of the total study area respectively. The future land cover projects that approximately 30 percent of the total study area will remain forested. Similarly, agricultural lands decline from 26 to 22 percent of the total and are projected to only represent 9 percent of the study area in the future. Two to 3 percent of the study area was in a state of transition in the historical and existing land cover data while the future land cover assumed build out with no transitional acreage. Clearing activities and road footprints on the 1999 aerials indicated that most of these areas were developing into a residential use. While the percentage of commercial and industrial lands almost double with each progressive land cover, residential lands will eventually be the predominant land cover representing approximately half of the total study area in the future..

Table 1. Results: Comparison of major land cover categories.

Land Cover Category	Historical (1970s)	Existing (1999)	Future (2020)
Agricultural Lands	26%	22%	9%
Forested Lands / Open Space	64%	50%	30%
Commercial	1%	2%	5%
Industrial	0%	2%	4%
Residential	5%	20%	50%
Transitional	2%	3%	0%

CONCLUSION

The land cover development efforts for the Forsyth County, Hall County and City of Gainesville Community Watershed Assessment resulted in contiguous, digital, existing and future land cover data. Upon completion of the project, the completed data products were provided to the respective municipal planning departments at their request for use in their future planning and watershed protection efforts. The land cover has already been utilized for additional water and wastewater planning analysis.

Given the importance of quality land cover information in assessing non-point source pollution, its development can be seen as a secondary benefit of the national Total Maximum Daily Load (TMDL) development program. As each state establishes its TMDLs it will be forced to focus attention on current land development patterns and their affects on water resources. More robust land cover information will increase the reliability and effectiveness of watershed management programs.

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